Study of the effect of bismuth electrophysical properties of gallium phosphide single crystals

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ABSTRACT

Semeconductor compounds with is ovalent impurities, effect of bismuth electrophysical properties, processing into a growing crystal, electrical properties of Ga P, mobility of crystals , the interaction of bismuth with silicon

Keywords: *Semiconductors, crystallization, technological change, crystal, apperence.*

1. INTRODUCTION

As it is known [1.2], doping of A3B5 semiconductor compounds with isovalent impurities (IVP) significantly affects the properties of these materials, and the IVP can interact with background impurities, which is of interest for solving the most important problem of physics and technology of semiconductors - reducing the residual impurity background in crystals.

In this work, using the example of bismuth-doped single crystals of GaP and obtained by the Czochralski method, the possibility of using the interaction of impurity atoms in the liquid phase is shown, as a result of which a smaller amount of background impurity gets into the growing crystal.

The cultivation was carried out by crystallization from the liquid phase under a layer of B2O3 flux, the thickness of which did not exceed 1 cm. An increase in the layer thickness leads to a decrease in its strength and makes it difficult to visually observe the appearance of primary crystals: and a decrease leads to an increase in the evaporation of volatile components.

Currently, there are 5 main types of promising and long-term alternative energy sources: solar energy, wind energy, hydropower, geothermal energy, biomass energy.

The first photoelectric effect was discovered in 1839 by the French physicist A. Beckerel. However, it was neglected until 1883, when Carl Frist formed the first solar cell. He laid a very thin layer of gold on top of the semiconductor selenium, but its efficiency did not exceed 1%. Later, the Russian physicist Stoletov created the first solar element based on an external photoelectric effect. Albert Einstein won the Nobel Prize in Physics in 1921 for his explanation of the photoelectric effect in 1905. In 1946, Ressel Oil received a patent for a modern semiconductor QE. In a unit of time, the Sun emits 23 4 10 (kWh of energy into space. The lifespan of the Sun is several billion years and therefore it is an infinite source of energy.

2. MAIN PART

To study the various practical processes related to the Sun, the Solar Constance is called S0. The solar constant is the amount of energy per unit area perpendicular to the surface outside the Earth's atmosphere, and its average value is S0 = 1366 W / m2. Solar radiation E0 is direct and scattered. The value of solar radiation generated by the unit depends on many factors: the latitude of the place, the weather, the season, the angle of the surface relative to the Sun, etc. Solar radiation is electromagnetic radiation, mainly 0.28… 3 , The solar spectrum is divided into the following wavelengths: - Ultraviolet waves, consisting of waves in the range of 0.28… 0.38 μm, visible to the naked eye and about 2% of the spectrum; - Light waves in the range of 0.38… 0.78 μm, make up about 49% of the spectrum; - Infrared waves consist of waves in the range of 0.78… 3.0 μm and make up the remaining 49% of the main part of the spectrum. The rest of the solar spectrum is not important for the Earth's heat balance. Certain parts of the solar spectrum affect different processes differently (physical, physiological, biological, etc.). To calculate the energy reaching the Earth's atmosphere, multiply the Sun's constant S0 by the surface of a circle of radius R (R = 6371000m - Earth's radius) and take into account that only 47% of this energy reaches the Earth's surface as a result of absorption, return and scattering in the Earth's atmosphere. As a result, we get the following expression for the energy W0 (power) falling on the Earth's surface in a unit of time: 2 16 WSR kW 0 0 (((((0, 47 8,18 10) The calculated value of W0 is slightly different from the values given in different sources , which can be explained by the fact that they used a coefficient of 0.47 and different values for S0 than us.The amount of solar energy entering the territory of the republic can also be shown in figures. The ratio of the energy of the Republic to the surface Wu to the total energy W0 is the ratio of the area of the territory of the Republic Au to the surface of the hemisphere A0. For our Republic it is 12 2 A m (4, 474 * 10. So 2 15 0 0 0 * * (2) 0,0176 * 1, 44 * 10 uuou AWWWARW kWt A (((((This energy is the whole of our Republic Solar cells are electronic devices that convert solar radiation into direct electricity. A sample of several phototransformers placed in a precise sequence on a substrate The Sun modulus (QM). QEs can be classified according to the amount of elements attached to a substrate, the crystal structure and thickness of the layer, the chemical composition, etc., the intensity of light collection. Depending on the crystalline properties of the light-absorbing material. QE can be divided into single crystals, multicrystals, polycrystals, microcrystals, nanocrystals. They are divided into types by size, ie multicrystals at 1-100 mm, polycrystals at 1-1000 microns, microcrystals smaller than 1 microns. crystal, a small nanocrystal at 1nm is called QE. Depending on the thickness of the light-absorbing material, QE skirts are divided into film and thick film. The thickness of QE with a thin film is several microns, with a thick film is 10-100 microns. Today's notions of solar cells, batteries, and photovoltaic devices date back 50 years, and over the past 25 years they have entered the economy and the lives of ordinary people as a source of energy. A solar cell is a set of photocells that is a means of converting light energy into electricity. The essence of these devices

is the absorption of solar radiation in semiconductor materials and the resulting potential barriers of charge pairs formed in the semiconductor. based on the processes of separation and transmission to an external electrical circuit.

Its electrical parameters are measured under normal lighting conditions (approximately the width of Tashkent corresponds to the dawn of a hot spring day). Photocells and solar cells are characterized by the production technology of the maximum output power, operating and maximum voltages, currents, efficiency of conversion of light energy into electricity. The use of solar energy is achieved by converting light into electricity using photocells - solar cells. Japan, Germany and the United States are leading in this regard. Generating heat energy using solar collectors - solar furnaces - the surface area of solar furnaces is measured by 21 million square meters. Japan, Israel and Greece are in the lead in this regard. Today, solar photovoltaic plants and collectors of solar water heating are successfully used in Surkhandarya, Jizzakh, Bukhara, Navoi, Tashkent, Andijan regions and the Republic of Karakalpakstan. As a result of fundamental research in the early period, it was found that the complete absorption of the spectrum of solar radiation depends on the properties of the material. It was found that the formation of charge pairs of absorbed radiation in the volume of the material and the process of their separation depends on the potential barrier (n - p transition) formed inside the semiconductor material and the properties of the material. This allowed to optimize the parameters of solar cells. Practical research includes the design and manufacture of QE structures with optimal parameters, the study of their properties, the development of technology of QE, batteries and photovoltaic devices, based on which different designs, operating in different conditions, Dedicated to the production of power supply systems for consumers of different capacities. Modern QE is made of different semiconductor materials, depending on the conditions under which it is used (in space, on Earth, in direct - direct solar radiation, concentrated solar radiation, in extreme cases, etc.). Most of the QE currently produced and used as a source of electricity for human consumption is made of silicon. The main reason for this is that silicon is the basis of microelectronic devices, which are widely used in modern economy. Second, silicon is an elemental semiconductor, which makes up about 30% of the Earth's composition, as well as the development of technology. Currently, with the advent of solar-based semiconductor silicon compounds, the demand for semiconductor devices based on these compounds is growing. One of the main tasks is to study the electrophysical properties of each solar cell and create new devices based on them. Solar elements are semiconductor materials that work on and convert solar energy. The advent of semiconductor devices based on sunlight has led to low-cost, high-performance diode structures. Solar elements can consist of a semiconductor element, heterostructures with atoms of semiconductor compounds or many elements. Depending on the structure, the physical characteristics vary. Characteristics of the crystals that make up the elements of the sun include the intensity of light, the visible type of wavelength, the intensity of radiation. Omlik contacts of light crystals are made on the basis of skirt film technology. With the structure of solar elements from heterostructures, the efficiency of space efficiency is increasing. The main method of growing semiconductor heterostructures based on solar elements is the method of hydride epitaxy, and structures grown in this way have a great potential for use in space.

Doping with bismuth does not introduce additional hardware and technological changes in the process of growing GaP <Bi> single crystals. It was only required to select the required amount of bismuth added to the charge to reduce the evaporation of volatile components.

The chamber was filled with argon until a pressure of 6x106 Pa was reached (after heating the setup), after which high-frequency heating was switched on until the flux was completely melted, and then, while the crucible was rotating at a certain speed for homogenization, the charge. The starting material was polycrystalline gallium phosphide with bismuth additives in an amount of 0.00 to 0.05 mol% [3].

Study of the content of bismuth in gallium phosphide made it possible to establish that the solubility of Bi in GaP is very low (less than 10-5 mol.%). If we assume that Bi in GaP is in the phosphide substitution position, then it is not an electroactive impurity.

With the introduction of Bi more than 0.05 mol%, the precipitation of the second phase was observed in the obtained crystals, and at a low content (<0.01 mol%), no effect on the electrical properties of GaP was found.

The electrophysical characteristics of GaP <Bi> single crystals were studied by the van der Pauve method, i.e. studied the effect of bismuth on the concentration and mobility of charge carriers in gallium phosphide. GaP single crystals obtained from the melt and containing bismuth in the indicated concentration range had [4] the mobility on average 40% higher than that of undoped crystals (Table).

Mass spectrometric analysis with a spark source showed that in GaP polycrystals the silicon content was 2x10-3 at%, and in GaP single crystals <Bi> in the upper part 2x10-5 at% and in the lower part 9x10-6 at% silicon. The bismuth content was less than 10-5 at%. Apparently, an increase in the mobility in GaP <Bi> crystals is associated with a strong decrease in the silicon content. In this case, bismuth does not introduce any additional energy levels into the band gap of gallium phosphide.

The interaction of bismuth with silicon leads to a decrease in the distribution coefficient of silicon, as a result of which a smaller amount of this impurity gets into the growing crystal. The interaction of bismuth and residual silicon atoms can also occur in the solid phase. In this case, the crystal is "purified" due to the formation of stable associated complexes of atoms, facilitating the transition of residual impurities into an

inactive state.

3. CONCLUSION

The effect of doping with bismuth on the electrophysical properties of gallium phosphide has been studied. It is shown that an increase in the bismuth content from 0.01 to 0.05 mol.% In the initial melt leads to a decrease in the carrier concentration and an increase in the mobility, as well as to a decrease in the concentration of residual silicon in single crystals.

Table

№	Content of bismuth mol%	Concentration carries charge n, cm^{-3}	Mobility μ, cm^{-2} (B.c)	Dislocation density N_d, cm^{-2}	Second phase presence
1	FGE5-16	$4\text{-}5x10^{16}$	140	$6.6x10^4$	no
2	0,01	$6.2x10^{16}$	172	$4.2x10^4$	no
3	0,03	$3.2x10^{16}$	185	$2.0x10^4$	no
4	0,05	$6.4x10^{16}$	201	$7.8x10^3$	no

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